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(54) Method and apparatus for providing proxying and transcoding of documents in a distributed network

(57) A method of providing a document to a client coupled to a server is provided. The server provides a number of Internet services to the client, including functioning as a caching proxy on behalf of the client for purposes of accessing the World Wide Web. The proxying server includes a persistent document database, which stores various attributes of all documents previously retrieved in response to a request from a client. When a Web document is retrieved from a remote server in response to a request from the client, the database is consulted and the stored information relating to the requested document is used by the server in transcoding the document. The document is transcoded for various purposes, including to circumvent bugs or quirks found in the document, to size the document for display on a television set, to improve transmission efficiency of the document, and to reduce latency. The transcoder makes use of the document database to perform these functions. The document database is also used for prefetching previously requested documents and images and for reducing latency when downloading images to the client.

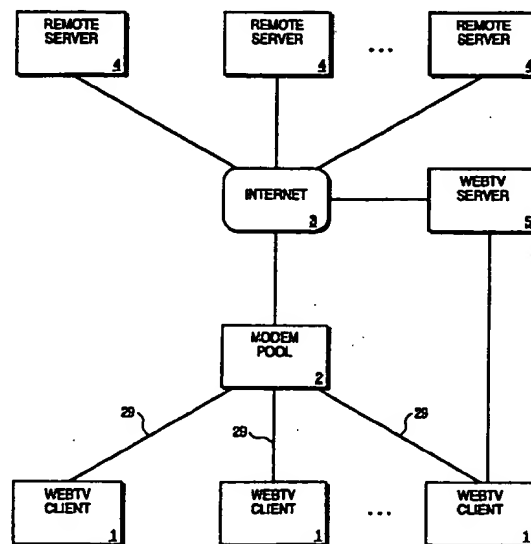


FIG. 1

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Figure 2 illustrates a client according to the present invention.

Figure 3 is a block diagram of a server according to the present invention.

Figure 4A illustrates a server including a proxy cache and a transcoder.

Figure 4B illustrates databases used in a server according to the present invention.

Figure 5 is a flow diagram illustrating a routine for transcoding a document retrieved from a remote server using data stored in a persistent database.

Figure 6 is a flow diagram illustrating a routine for transcoding an HTML document for purposes of eliminating bugs or undesirable features.

Figure 7 is a flow diagram illustrating a routine for reducing latency when downloading a document referencing an image to a client.

Figure 8 is a flow diagram illustrating a routine for updating documents stored in the proxy cache using data stored in a persistent database.

Figure 9 is a flow diagram illustrating a routine used by a server for retrieving documents from another remote server.

Figure 10 is a block diagram of a prior art server system showing a relationship between various services and a database.

Figure 11 is a block diagram of a server system according to the present invention showing a relationship between various services and a user database.

Figure 12 is a flow diagram illustrating a routine used by a server for regulating access to various services provided by the server.

DETAILED DESCRIPTION

A method and apparatus are described for providing proxying and transcoding of documents in a network. In the following description, for purposes of explanation, numerous specific details are set forth in order to provide a thorough understanding of the present invention. It will be evident, however, to one skilled in the art that the present invention may be practiced without these specific details. In other instances, well-known structures and devices are shown in block diagram form in order to avoid unnecessarily obscuring the present invention.

The present invention includes various steps, which will be described below. The steps can be embodied in machine-executable instructions, which can be used to cause a general-purpose or special-purpose processor programmed with the instructions to perform the steps. Alternatively, the steps of the present invention might be performed by specific hardware components that contain hardwired logic for performing the steps, or by any combination of programmed computer components and custom hardware components.

I. System Overview

The present invention is included in a system, known as WebTV™, for providing a user with access to the Internet. A user of a WebTV™ client generally accesses a WebTV™ server via a direct-dial telephone (POTS, for "plain old telephone service"), ISDN (Integrated Services Digital Network), or other similar connection, in order to browse the Web, send and receive electronic mail (e-mail), and use various other WebTV™ network services. The WebTV™ network services are provided by WebTV™ servers using software residing within the WebTV™ servers in conjunction with software residing within a WebTV™ client.

Figure 1 illustrates a basic configuration of the WebTV™ network according to one embodiment. A number of WebTV™ clients 1 are coupled to a modem pool 2 via direct-dial, bi-directional data connections 29, which may be telephone (POTS, i.e., "plain old telephone service"), ISDN (Integrated Services Digital Network), or any other similar type of connection. The modem pool 2 is coupled typically through a router, such as that conventionally known in the art, to a number of remote servers 4 via a conventional network infrastructure 3, such as the Internet. The WebTV™ system also includes a WebTV™ server 5, which specifically supports the WebTV™ clients 1. The WebTV™ clients 1 each have a connection to the WebTV™ server 5 either directly or through the modem pool 2 and the Internet 3. Note that the modem pool 2 is a conventional modem pool, such as those found today throughout the world providing access to the Internet and private networks.

Note that in this description, in order to facilitate explanation the WebTV™ server 5 is generally discussed as if it were a single device, and functions provided by the WebTV™ services are generally discussed as being performed by such single device. However, the WebTV™ server 5 may actually comprise multiple physical and logical devices connected in a distributed architecture, and the various functions discussed below which are provided by the WebTV™ services may actually be distributed among multiple WebTV™ server devices.

II. Client System

Figure 2 illustrates a WebTV™ client 1. The WebTV™ client 1 includes an electronics unit 10 (hereinafter referred to as "the WebTV™ box 10"), an ordinary television set 12, and a remote control 11. In an alternative embodiment of the present invention, the WebTV™ box 10 is built into the television set 12 as an integral unit. The WebTV™ box 10 includes hardware and software for providing the user with a graphical user interface, by which the user can access the WebTV™ network services, browse the Web, send e-mail, and otherwise access the Internet.

The WebTV™ client 1 uses the television set 12 as

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ical and diagnostic information for every Web page that is accessed at any time by a WebTV™ client 1. As is well known, a Web page may correspond to a document written in a language such as HTML (Hypertext Markup Language), VRML (Virtual Reality Modelling Language), or another suitable language. Alternatively, a Web page may represent an image, or a document which references one or more images. According to the present invention, once a document or image is retrieved by the WebTV™ server 5 from a remote server 4 for the first time, detailed information on this document or image is stored permanently in the document database 61. More specifically, for every Web page that is retrieved from a remote server 4, any or all of the following data are stored in the document database 61:

- 1) information identifying bugs (errors) or quirks in the Web page, or undesirable effects caused when the Web page is displayed by a client 1;
- 2) relevant bug-finding algorithms;
- 3) the date and time the Web page was last retrieved;
- 4) the date and time the Web page was most recently altered by the author;
- 5) a checksum for determining whether the Web page has been altered;
- 6) the size of the Web page (in terms of memory);
- 7) the type of Web page (e.g., HTML document, image, etc.);
- 8) a list of hypertext anchors (links) in the Web page and corresponding URLs;
- 9) a list of the most popular anchors based on the number of "hits" (requests from a client 1);
- 10) a list of related Web pages which can be prefetched
- 11) whether the Web page has been redirected to another remote server 4;
- 12) a redirect address (if appropriate);
- 13) whether the redirect (if any) is temporary or permanent, and if permanent, the duration of the redirect;
- 14) if the Web page is an image, the size of the image in terms of both physical dimensions and memory space;
- 15) the sizes of in-line images (images displayed in text) referenced by the document defining the Web page;
- 16) the size of the largest image referenced by the document;
- 17) information identifying any image maps in the Web page;
- 18) whether to resize any images corresponding to the Web page;
- 19) an indication of any forms or tables in the Web page;
- 20) any unknown protocols;
- 21) any links to "dead" Web pages (i.e., pages which are no longer active);
- 22) the latency and throughput of the remote server

- 4 on which the Web page is located;
- 23) the character set of the document;
- 24) the vendor of the remote server 4 on which the Web page is located;
- 25) the geographic location of the remote server 4 on which the Web page is located;
- 26) the number of other Web pages which reference the subject Web page;
- 27) the compression algorithm used by the image or document;
- 28) the compression algorithm chosen by the transcoder;
- 29) a value indicating the popularity of the Web page based on the number of hits by clients; and
- 30) a value indicating the popularity of other Web pages which reference the subject Web page.

B. Transcoding

As mentioned above, the WebTV™ services provide a transcoder 66, which is used to rewrite certain portions of the code in an HTML document for various purposes. These purposes include: (1) correcting bugs in documents; (2) correcting undesirable effects which occur when a document is displayed by the client 1; (3) improving the efficiency of transmission of documents from the server 5 to the client 1; (4) matching hardware decompression technology within the client 1; (5) resizing images to fit on the television set 12; (6) converting documents into other formats to provide compatibility; (7) reducing latency experienced by a client 1 when displaying a Web page with in-line images (images displayed in text); and, (8) altering documents to fit into smaller memory spaces.

There are three transcoding modes used by the transcoder 66: (1) streaming, (2) buffered, and (3) deferred. Streaming transcoding refers to the transcoding of documents on a line-by-line basis as they are retrieved from a remote server 4 and downloaded to the client 1 (i.e., transcoding "on the fly"). Some documents, however, must first be buffered in the WebTV™ server 5 before transcoding and downloading them to the client 1. A document may need to be buffered before transmitting it to the client 1 if the type of changes to be made can only be made after the entire document has been retrieved from the remote server 4. Because the process of retrieving and downloading a document to the client 1 increases latency and decreases throughput, it is not desirable to buffer all documents. Therefore, the transcoder 66 accesses and uses information in the document database 61 relating to the requested document to first determine whether a requested document must be buffered for purposes of transcoding, before the document is retrieved from the remote server 4.

In the deferred mode, transcoding is deferred until after a requested document has been downloaded to a client 1. The deferred mode therefore reduces latency experienced by the client 1 in receiving the document. Transcoding may be performed immediately after down-

quantified based upon the number of hits for that document, which is tracked in the document database 61. For example, it might be prudent to simply assign a relatively short period of validity to a document which is very popular and a longer period of validity to a document which is less popular.

Another alternative basis for the validity of a document is the observed rate of change of the document. Again, data in the persistent document database 61 can be used. That is, because the document database 61 stores the date and time on which the document was last observed to change, the server 5 can approximate how often the document actually changes. A document or image which is observed to change frequently (e.g., a weather map or a news page) can be assigned a relatively short period of validity. It will be recognized that numerous other ways of determining validity are possible.

2. Transcoding to Reduce Latency

Another purpose for transcoding is to allow documents requested by a client 1 to be displayed by the client 1 more rapidly. Many HTML documents contain references to "in-line" images, or images that will be displayed in text in a Web page. The normal process used in the prior art to display a Web page having in-line images is that the HTML document referencing the image is first downloaded to the client, followed by the client's requesting the referenced image. The referenced image is then retrieved from the remote server on which it is located and downloaded to the client. One problem associated with the prior art, however, is that the speed with which a complete Web page can be displayed to the user is often limited by the time it takes to retrieve in-line images. One reason for this is that it simply takes time to retrieve the image itself after the referencing document has been retrieved. Another reason is that, in the prior art, if the referencing document does not specify the size of the image, the Web page generally cannot be displayed until the image itself has been retrieved. The present invention overcomes these limitations.

According to the present invention, information stored in the document database 61 regarding the in-line images is used to transcode the referencing document in order to reduce latency in displaying the Web page. Once any document which references an in-line image is initially retrieved by the server 5, the fact that the document references an in-line image is stored in the document database 61. In addition, the size of the image is determined, either from the document (if specified) or from the image itself, and then stored in the document database 61. Consequently, for documents which do not specify the size of their in-line images, the size information stored in the database 61 is then used the next time the document is requested in order to reduce latency in downloading and displaying the Web page.

Refer now to Figure 7, which illustrates a routine for reducing latency when downloading a document referencing an image to a client 1. Assume that a client 1 sends a request to the server 5 for an HTML document containing a reference to an in-line image. Assume further that the size of the image is not specified in the document itself. Initially, the server 5 determines whether that document has been previously retrieved (step 701). If not, the standard initial retrieval and transcoding procedure is followed (step 706), as described in connection with Figure 6. If, however, the document has been previously retrieved, then the transcoder 66 accesses the size information stored in the document database 61 for the in-line image (step 702). Based on this size information, the HTML document is transcoded such that, when the Web page is initially displayed by the client 1, the area in which the image belongs is replaced by a blank region enveloping the shape of the image. Thus, any in-line image referenced by a document is displayed initially as a blank region. Consequently, the client 1 can immediately display the Web page corresponding to the HTML document even before the referenced image has been retrieved or downloaded (i.e., even before the size of the image is known to the client 1).

As the transcoded HTML document is downloaded to the client, the image is retrieved from the appropriate remote server 4 (step 704). Once the image is retrieved from the remote server 4 and downloaded to the client 1, the client 1 replaces the blank area in the Web page with the actual image (step 705).

3. Transcoding to Display Web Pages on a Television

As noted above, the client 1 utilizes an ordinary television set 12 as a display device. However, images in Web pages are generally formatted for display on a computer monitor, not a television set. Consequently, the transcoding function of the present invention is used to resize images for display on the television set 12. This includes rescaling images as necessary to avoid truncation when displayed on the television set 12.

It should be noted that prior art Web browsers which operate on computer monitors typically use resizable windows. Hence, the size of the visible region varies from client to client. However, because the web browser used by the WebTV™ client 1 is specifically designed for display on a television set, the present invention allows documents and images to be formatted when they are cached.

4. Transcoding for Transmission Efficiency

Documents retrieved by the server 5 are also transcoded to improve transmission efficiency. In particular, documents can be transcoded in order to reduce high frequency components in order to reduce interlace flicker when they are displayed on a television set.

Documents can also be transcoded in order to

5 to inform the client 1 of documents or images which are popular to allow the client 1 to perform the prefetching. In particular, for any given document, a list is maintained in the server 5 of the most popular hypertext anchors in that document (i.e., those which have previously received a large number of hits). When that document is requested by the client 1, the server 5 provides the client 1 with an indication of these popular links.

3. Redirects

Web pages are sometimes forwarded from the remote server on which they are initially placed to a different location. Under the HTTP (Hypertext Transport Protocol), such forwarding is sometimes referred to as a "redirect." When an HTML document is initially stored on one remote server and then later transferred to another remote server, the first remote server will provide, in response to a request for that document, an indication that the document has been transferred to a new remote server. This indication generally includes a forwarding address ("redirect address"), which is generally a URL.

In the prior art, when a computer requesting a Web page receives a redirect, it must then submit a new request to the redirect address. Having to submit a second request and wait for a second response consumes time and increases overall latency. Consequently, the present invention uses the document database 61 to store any redirect address for each document or image. Any time a redirected document is requested, the server 5 automatically accesses the redirect address to retrieve the document. The document or image is provided to the client 1 based on only a single request from the client 1. The change in location of the redirected document or image remains completely transparent to the client 1.

Figure 9 illustrates a routine performed by the server 5 in accessing documents which may have been forwarded to a new remote server. Initially, the server 5 receives a request for a document, which generally includes an address (step 901). The server 5 then accesses the document database 65 to determine whether there is a redirect address for the requested document (step 902). If there is no redirect address, then the server 5 accesses a remote server 4 based on the address provided in the document request from the client 1 (step 903). Assuming that the remote server 4 does not respond to the server 5 with a redirect (step 904), the document is retrieved and downloaded to the client 1 by the server 5 (step 907). If, however, a redirect address was stored in the document database 65 (step 902), then the server 5 accesses the requested document according to the redirect address (step 906). Or, if the remote server 4 responded with a redirect (step 904), then the server 5 saves the redirect address to the document database 61 (step 905) and accesses the requested document according to the redirect address (step 906).

4. Other Proxy Functions

The document database 65 also stores information relating to the performance of each remote server 4 from which a document is retrieved. This information includes the latency and throughput of the remote server 4. Such information can be valuable in instances where a remote server 4 has a history of responding slowly. For example, when the document is requested, this knowledge can be used by the server 5 to provide a predefined signal to the client 1. The client 1 can, in response to the signal, indicate to the user that a delay is likely and give the user the option of canceling the request.

5. Backoff Mode

Although the server 5 generally operates in the proxy mode, it can also enter a "backoff mode" in which the server 5 does not act as a proxy, or the server 5 performs only certain aspects of the normal proxying functions. For example, if the proxy cache 65 is overloaded, then the server 5 can enter a backoff mode in which documents are not cached but are transcoded as required. Alternatively, during times when the server 5 is severely overloaded with network traffic, the server 5 may instruct the client 1 to bypass the server 5 and contact remote servers 4 directly for a specified time or until further notice. Or, the server 5 can enter a flexible backoff mode in which the client 1 will be instructed to contact a remote server 4 directly only for certain Web sites for a limited period of time.

D. Access to WebTV™ Services

The WebTV™ server 5 provides various services to the client 1, such as proxying and electronic mail ("e-mail"). In the prior art, certain difficulties are associated with allowing a client computer access to different services of an Internet service, as will now be explained with reference to Figure 10.

Figure 10 illustrates a client-server system according to one prior art embodiment. The server 76 provides various services A, B, and C. The server 76 includes a database 71 for storing information on the user's access privileges to services A, B, and C. The client 75 of the embodiment of Figure 10 accesses any of services A, B, and C by contacting that service directly. The contacted service then accesses the database 71, which stores the access privileges of the client 75, to determine whether the client 75 should be allowed to access that service. Hence, each service provided by the server 76 requires direct access to the database 71. This architecture results in a large number of accesses being made to the database 71, which is undesirable. In addition, the fact that each service independently has access to the database 71 raises security concerns. Specifically, it can be difficult to isolate sensitive user information. The present invention overcomes such dif-

service. It should also be noted that separate service names can also refer to the same service.

Assume, for example, that the e-mail service provided by the WebTV™ system is designated by the service name "WTV-mailto." A client 1 can access any provider of this e-mail service using the same URL. The client 1 merely chooses the appropriate port number and IP number to distinguish between providers. If the client 1 is unable to connect to one e-mail provider, it can simply contact the next one in the list.

Thus, at log-in time, a client 1 is provided with both a ticket containing privileges and capabilities as well as a list of service providers, as illustrated in Figure 12. Initially, the log-in service 78 determines whether the user of client 1 is a valid user (step 1201). If not, log-in is denied (step 1205). If the user is a valid user, then the log-in service 78 gathers user information from the user database 62 and generates a ticket 82 (step 1202). The log-in service 78 also generates the above-described list of services (step 1203). The ticket 82 and the list of services are then downloaded to the client 1 (step 1204).

3. Asynchronous Notification to Clients by Server

Another limitation associated with prior art Internet servers is the inability to provide asynchronous notification information to the client in the absence of a request from the client to do so. It would be desirable, for example, for a server to notify a client on its own initiative when a particular Web page has changed or that a particular service is inaccessible. The server 5 of the present invention provides such capability, and the client 1 is configured to receive and decode such notifications. For example, the client 1 can receive updates of its listing of service providers from the server 5 at various points in time, as already described. Similarly, if a particular service provider becomes unavailable, that fact will be automatically communicated to the client 1. As another example, if e-mail addressed to the user has been received by the server 5, then the server 5 will send a message to the client 1 indicating this fact. The client 1 will then notify the user that e-mail is waiting by a message displayed on the television set 12 or by an LED (light emitting diode) built into the housing of WebTV™ box 10.

Thus, a method and apparatus have been described for providing proxying and transcoding of documents in a network. Although the present invention has been described with reference to specific exemplary embodiments, it will be evident that various modifications and changes may be made to these embodiments without departing from the broader spirit and scope of the invention as set forth in the claims. Accordingly, the specification and drawings are to be regarded in an illustrative rather than a restrictive sense.

Claims

1. In a proxying server coupled to a client and to a remote server, the proxying server operating as a proxy on behalf of the client for accessing the remote server, a method of providing a first document to the client, the method comprising the steps of:
 - retrieving the first document from the remote server in response to a request from the client, the document including data for causing the client to generate a display;
 - using the proxying server to alter the data in the first document to form a transcoded document; and
 - transmitting the transcoded document to the client.
2. A method according to claim 1, wherein the step of using the proxying server to alter the data in the first document comprises the steps of:
 - analyzing the data to determine whether a predetermined condition is present in the data, wherein the predetermined condition comprises data which, when used by the client, causes an error condition to occur; and
 - if the predetermined condition is present in the data, revising the data to eliminate the predetermined condition.
3. A method according to claim 1, wherein the step of transmitting the transcoded document to the client is performed prior to performing the step of using the proxying server to alter the data in the first document.
4. A method according to claim 1, wherein the client includes a television display, wherein the document references an image, and wherein the step of using the proxying server to alter the data in the document comprises the step of revising the data such that the image is sized for display on the television display.
5. A method according to claim 1, further comprising the steps of:
 - retrieving an image from the remote server in response to a request from the client, wherein the image has a first image format; and
 - using the proxying server to convert the image from the first image format to a second image format.
6. A method according to claim 1, wherein the first document includes a link to a second document, the link including a first address, and wherein the

using the second service to receive a second access request from the client, the second access request for requesting use of the second service by the client, the second access request including a copy of the information packet; and

using the copy of the information packet to regulate access by the client to the second service.

21. A method according to claim 20, wherein the plurality of on-line services are Internet services.

22. A method according to claim 20, wherein the second service is a proxy service by which the server functions as a proxy on behalf of the client for purposes of accessing a second server.

23. In server system coupled to a client, a method of providing the client with a plurality of redundant services, each of the redundant services being substantially equivalent to each of the other redundant services, the method comprising the steps of:

providing the client with a service name applicable to all of the redundant services;

providing the client with a unique port number for each service;

providing the client with a unique protocol for each service;

receiving a request to access one of the redundant services from the client, the request including an address specifying the service name; and

granting access to one of the redundant services in accordance with the name included in the address, one of the port numbers and one of the protocols, such that the client uses the same address to access any of the redundant services.

24. A method according to claim 1, wherein the address is a URL (Uniform Resource Locator)

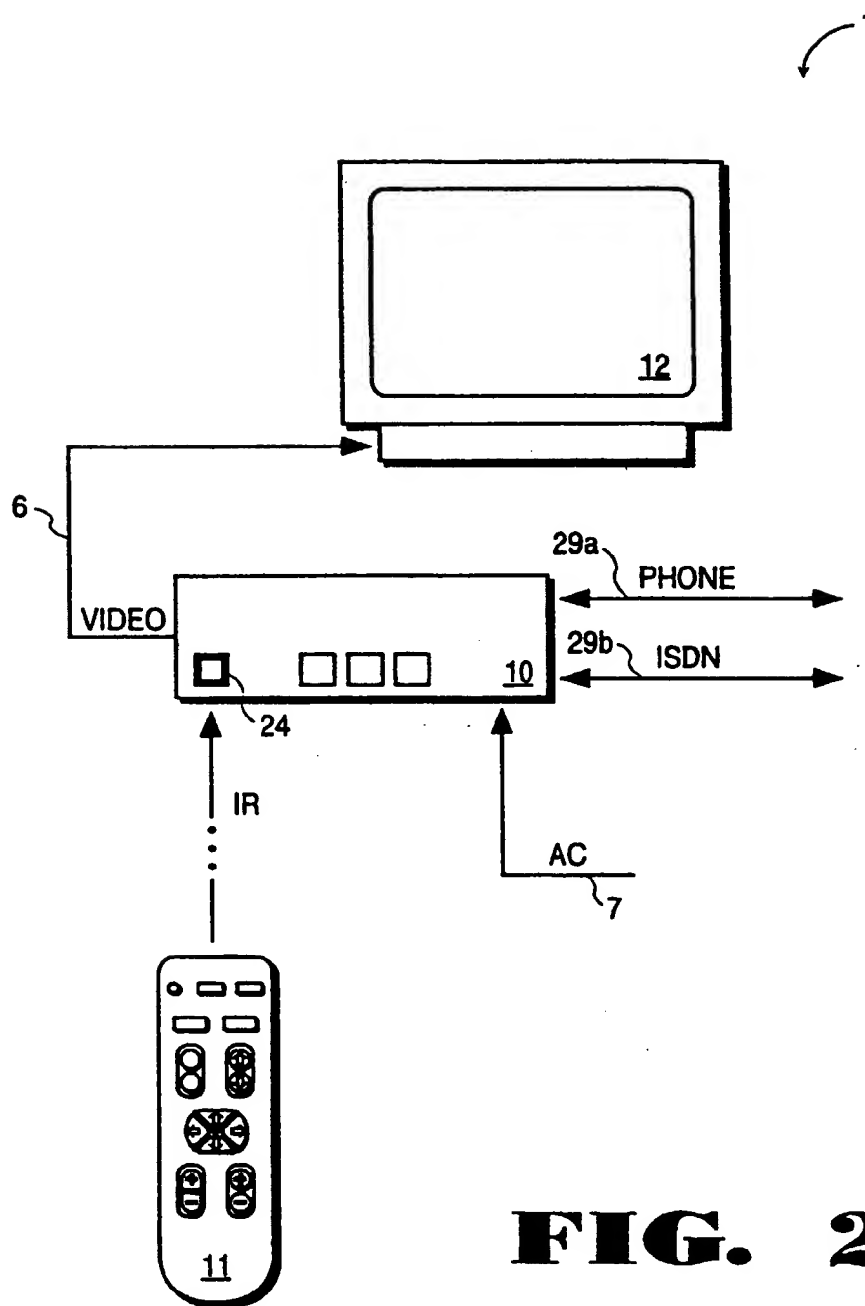


FIG. 2

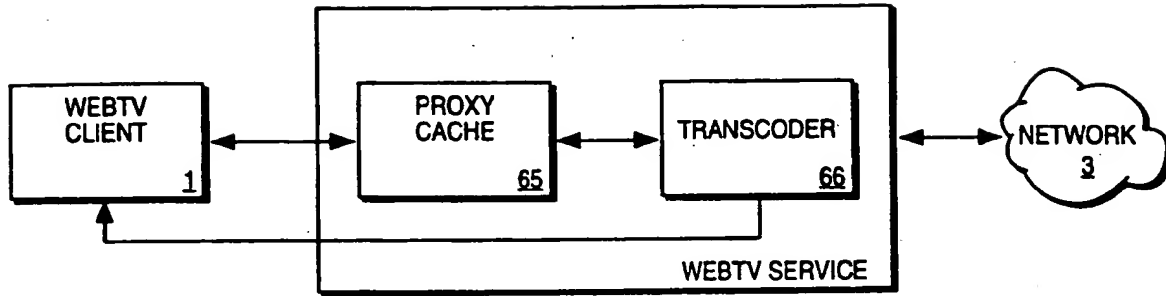


FIG. 4A

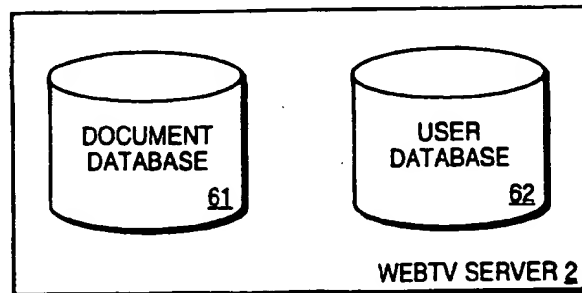
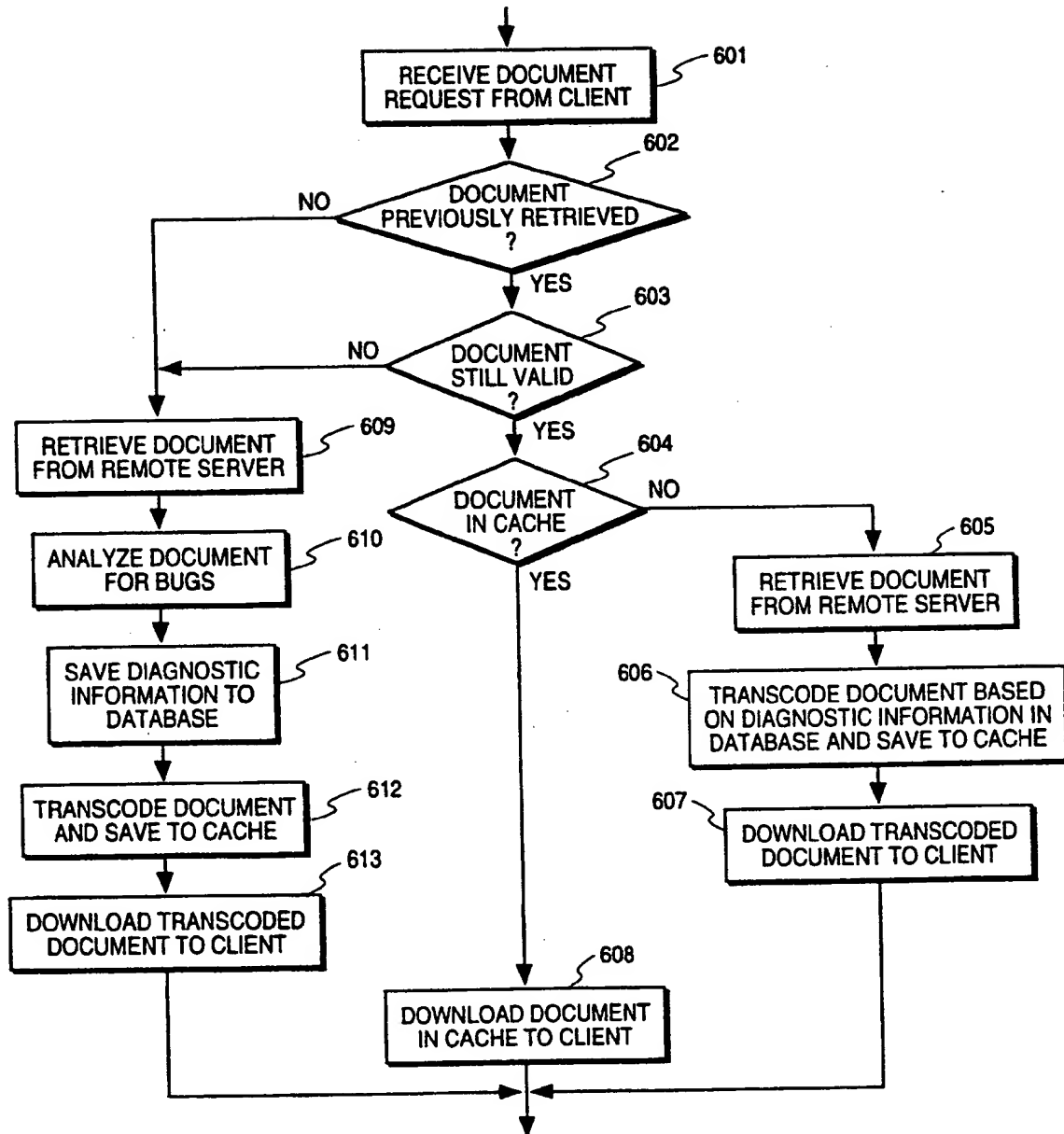
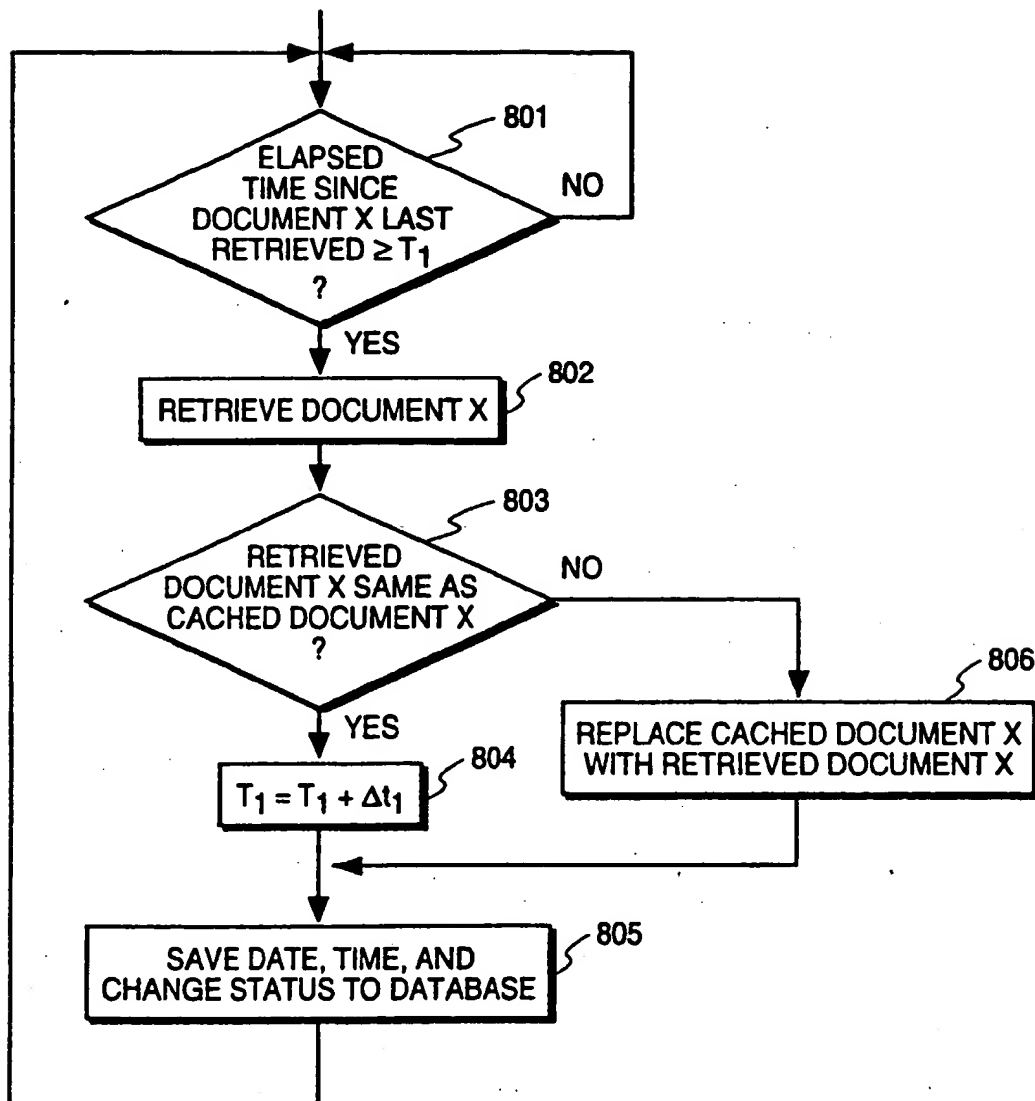


FIG. 4B

**FIG. 6**

**FIG. 8**

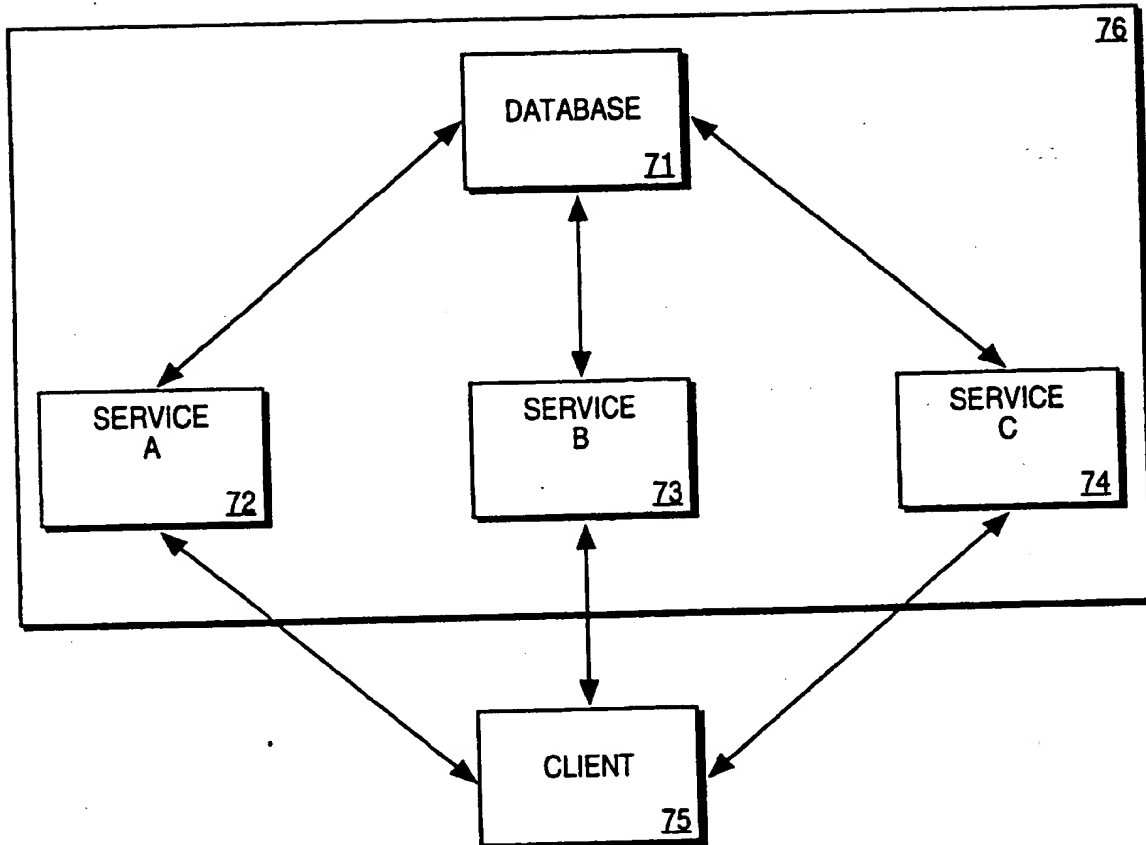
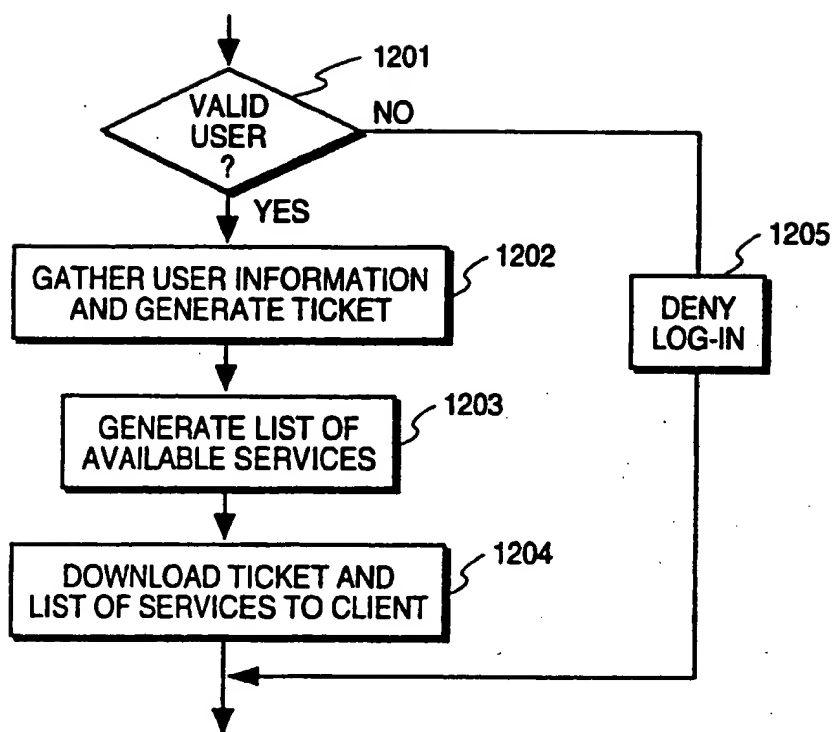
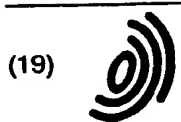


FIG. 10 (PRIOR ART)

**FIG. 12**



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(54) Method and apparatus for providing proxying and transcoding of documents in a distributed network

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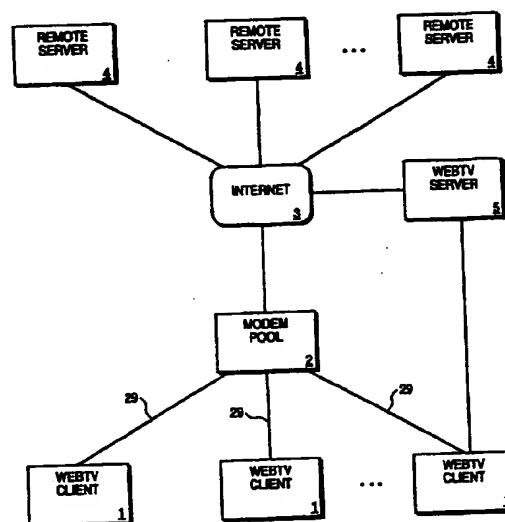


FIG. 1

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European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 97 30 2827

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A	SCHULZRINNE H: "WORLD WIDE WEB: WHENCE, WHITHER, WHAT NEXT?" IEEE NETWORK: THE MAGAZINE OF COMPUTER COMMUNICATIONS, vol. 10, no. 2, 1 March 1996, pages 10-17, XP000570608 * page 16, column 2, line 37 - page 16, column 2, line 50 * -----	1,4	
			TECHNICAL FIELDS SEARCHED (Int.Cl.6)
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 11 November 1998	Examiner Abbing, R
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